

Phase-Differentiated Black Hole Cosmology: A Framework for Nested Universes, Variable Constants, and CPT-Generalized Horizon Transitions

Franz Kruhm
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Abstract

We propose a cosmological framework in which black hole horizons function as phase-transition boundaries between causally isolated universes. Extending CPT-symmetric cosmology (Boyle, Finn & Turok 2018) and Cosmological Natural Selection (Smolin 1992), we argue that the phase relationship imposed at a horizon need not be a strict CPT reversal, but may vary continuously as a function of black hole parameters — mass, spin, and charge. This generalization implies that child universes inherit not fixed physical constants but phase-dependent constants, with no privileged scale. The observable universe is reframed as the interior of a black hole whose horizon imposed a specific phase shift on a parent-universe vacuum, explaining the apparent fine-tuning of constants as geometric inheritance rather than anthropic selection. We further propose that Hawking radiation encodes the phase-conjugate signature of infalling matter — constituting the symmetry-required exit — and that extreme time dilation at the horizon explains why this emission appears as a trickle from our reference frame, while the final evaporation burst represents the complete readout of a black hole's accumulated history. The framework implies no privileged beginning: the Big Bang was an ordinary gravitational collapse in a parent universe, one of an unbounded recursive population of such events, with no requirement for a first cause.

1. Introduction

The standard cosmological model offers no account of why the fundamental constants — the fine structure constant, the speed of light, the cosmological constant — take the values they do, nor why the Big Bang occurred at all. Anthropic selection arguments, while logically consistent, are explanatorily unsatisfying. Smolin's Cosmological Natural Selection (CNS) proposed that black hole formation events seed child universes with slightly mutated constants, yielding a Darwinian landscape of cosmologies. Separately, Boyle, Finn and Turok proposed that the Big Bang produced two universes related by CPT symmetry — a matter universe running forward in time, and its conjugate running backward, together forming a globally CPT-symmetric system invisible to each other by construction.

The framework presented here synthesises and extends both proposals. We argue that: (1) black hole horizons are phase boundaries between universes; (2) the phase relationship at each horizon is not restricted to CPT reversal but is a continuous function of horizon geometry; (3) physical constants are not inherited with mutation, but are determined by the phase shift itself; (4) there is no privileged scale — the nesting of universes within black holes within universes is self-similar and unbounded in both directions; and (5) there is no privileged beginning — the question of first cause is dissolved by the recursive structure itself.

2. The Horizon as Phase Boundary

General relativity's maximally extended Schwarzschild solution (Kruskal-Szekeres coordinates) already contains four spacetime regions: two exterior regions, a black hole interior, and a white hole interior. The white hole — thermodynamically disfavoured in our universe — is precisely what phase-reversal symmetry demands: if matter transits inward at a black hole, its conjugate must transit outward somewhere. The resolution to the apparent absence of white holes is that they exist, but are phase-shifted out of observational reach.

We define a generalised phase operator Φ acting on quantum fields at the horizon. In the Boyle-Turok model, $\Phi = \text{CPT}$. We propose instead:

$$\Phi(M, J, Q) = C^{\alpha} * P^{\beta} * T^{\gamma}$$

where M, J, Q are black hole mass, angular momentum, and charge respectively, and α, β, γ are continuous parameters determined by horizon geometry. Pure CPT reversal is recovered as a special case. A Kerr black hole ($J \neq 0$) has a ring singularity and an extended Penrose diagram with additional interior regions — geometrically distinct from the Schwarzschild case — suggesting a genuinely different phase relationship at its horizon.

3. Variable Constants as Phase Inheritance

If physical constants in a child universe are determined by Φ , and Φ varies with black hole parameters, then different black holes produce child universes with different constants. Critically, this includes the speed of light c , which we treat not as a universal invariant but as a phase-dependent parameter of each universe's local vacuum structure. Scale itself — the relationship between length, time, and energy — is set by the phase shift at the originating horizon.

This implies no privileged scale exists across the full ensemble. What we call 'the speed of light' is the locally stable vacuum parameter of our particular phase-shifted universe. Observers in a child universe of different phase would measure a self-consistent c' , with no experiment available to either observer to detect the discrepancy — they are causally isolated by construction.

This resolves the fine-tuning problem without anthropic selection: our constants are what they are because our universe was born from a black hole that imposed a specific Φ . The question

'why these constants?' becomes 'what were the parameters of our parent black hole?' — a question in principle answerable if a mapping between Φ and constants can be derived.

4. Hawking Radiation as the Phase-Conjugate Exit

A phase-reversal model demands that if matter enters at the black hole horizon, its phase conjugate must exit. The apparent violation of this — the absence of observable white holes — is resolved by noting that Hawking radiation already satisfies this requirement. In the standard derivation, virtual particle pairs near the horizon result in one particle escaping and the other falling inward. The escaping particle is, in a precise quantum field theoretic sense, the CPT conjugate of the infalling partner.

Under the generalised phase operator $\Phi(M, J, Q)$, Hawking radiation is the phase-conjugate emission corresponding to whatever phase shift the specific horizon imposes. This reframes the information paradox: information is not lost, it is phase-shifted. The outgoing radiation encodes the complete state of infalling matter in the conjugate phase, which is precisely why it appears thermal and information-free to observers in the original phase — they lack the conjugate detector required to decode it.

5. Time Dilation, Emission Rate, and the Final Burst

A natural question arises: if the phase-conjugate exit exists, why do we measure only vanishingly small Hawking emission from astrophysical black holes? The answer lies in the causal structure of the horizon itself. From any external reference frame, time dilation at the event horizon is formally infinite — infalling matter appears to freeze asymptotically, redshifting into invisibility without ever crossing. The speed of light, as the invariant that defines the causal structure of spacetime, is directly responsible for this dilation relationship.

Consequently, the rate at which the horizon 'processes' infalling matter — and emits its phase-conjugate output — is set by the ratio of the black hole's proper time to our coordinate time. For stellar mass black holes this produces Hawking temperatures of order 10^{-8} Kelvin, far below any detectable threshold. We are not measuring a small signal. We are measuring the correct signal for our position in the time dilation gradient.

This picture implies a striking endpoint. Hawking evaporation is not uniform — the emission rate accelerates as mass decreases, culminating in a final burst as the remaining mass converts entirely to radiation. In the phase-shift framework, this final burst is not featureless thermal noise but the complete phase-conjugate readout of everything the black hole ever absorbed — the entire accumulated history of that cosmic interior, emitted in a single event. The black hole does not die. It finishes translating.

The far future universe — past all star formation, past all ordinary matter — consists of black holes of decreasing mass evaporating on staggered timescales, each final burst a complete chapter of phase-encoded cosmic history. The ensemble of evaporation events constitutes, in aggregate, the complete readout of our universe's interior history into the parent universe.

6. Self-Similar Nesting and the Dissolution of First Cause

The framework is self-similar by construction. Our observable universe is the interior of a black hole in a parent universe. The black holes our universe contains are the birth events of child universes. There is no ground level — no smallest or largest universe — and no privileged scale at which the nesting terminates. This is consistent with scale relativity (Nottale 1993), which holds that the laws of physics should be independent of the scale at which they are expressed.

Crucially, this structure dissolves the question of first cause entirely. The Big Bang was not a unique or singular event requiring special explanation. It was an ordinary gravitational collapse in a parent universe — one of an enormous population of such collapses, each seeding a child universe. Our galaxy alone contains hundreds of millions of black holes; the observable universe contains an estimated 10^{17} to 10^{18} stellar mass black holes. Each is potentially a universe. Each of those universes contains comparable populations of black holes of their own.

Time itself is local to each universe, set by its phase-shift-determined vacuum parameters. There is no global time across the nesting within which a 'first' event could occur. The concept of a beginning requires a container with a temporal axis — the recursive structure provides no such container. The universe is not something that started. It is something that, at our level of the nesting, has always been in the process of black holes collapsing into one another across timescales that render the current age of the observable universe negligible.

Each level of nesting is causally isolated from adjacent levels. Parent universes cannot observe child universes. Child universes cannot observe parent universes. The ensemble is consistent with all current observational constraints while being, in principle, empirically distinguishable from alternatives if a mapping between Φ and constants is established.

7. Discussion and Predictions

The phase-shift framework makes several predictions distinguishable from both standard CNS and pure CPT cosmology:

7.1 Black hole parameters should correlate with child universe constants in a structured, non-random way. If a mapping $\Phi(M, J, Q) \rightarrow \{c, \hbar, G, \alpha \dots\}$ can be derived from first principles, it would constitute a predictive theory of constants rather than a selection argument.

7.2 Hawking radiation from black holes of different spin should differ in subtle quantum correlations beyond the thermal spectrum — a signature of the different phase operators at Kerr versus Schwarzschild horizons.

7.3 The Big Bang should exhibit CPT-like symmetry in its initial conditions — consistent with the Boyle-Turok prediction — but with specific phase parameters determined by parent black hole geometry rather than exact CPT reversal.

7.4 The final evaporation burst of any black hole should carry non-thermal correlations encoding the phase-conjugate history of its interior. Detection of such structure in primordial micro-black-hole evaporation events would constitute direct evidence for the framework.

8. Conclusion

We have outlined a framework in which black hole horizons are generalised phase boundaries; physical constants are determined by the phase shift imposed at each universe's birth horizon; Hawking radiation constitutes the required phase-conjugate exit at a rate set by horizon time dilation; the final evaporation burst is the complete readout of a black hole's interior history; and the structure of reality is self-similar across scales with no privileged level and no privileged beginning. The framework synthesises and extends CPT-symmetric cosmology and Cosmological Natural Selection, resolving the fine-tuning problem through geometric inheritance, the information paradox through phase-encoding, and the question of first cause through recursive dissolution.

The central open question is the derivation of the explicit mapping $\Phi(M,J,Q) \rightarrow$ physical constants. This constitutes the primary theoretical programme implied by the framework. The secondary programme is the detection of non-thermal correlations in Hawking-like radiation, which would provide the first observational handle on the phase structure of horizons.

Revision notes (v0.1 $\rightarrow$ v0.2): Added Section 5 on time dilation as the mechanism governing emission rate and the significance of the final evaporation burst. Extended Section 6 to incorporate the dissolution of first cause and the recursive population argument. Updated abstract and conclusion accordingly. Added prediction 7.4.

References

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